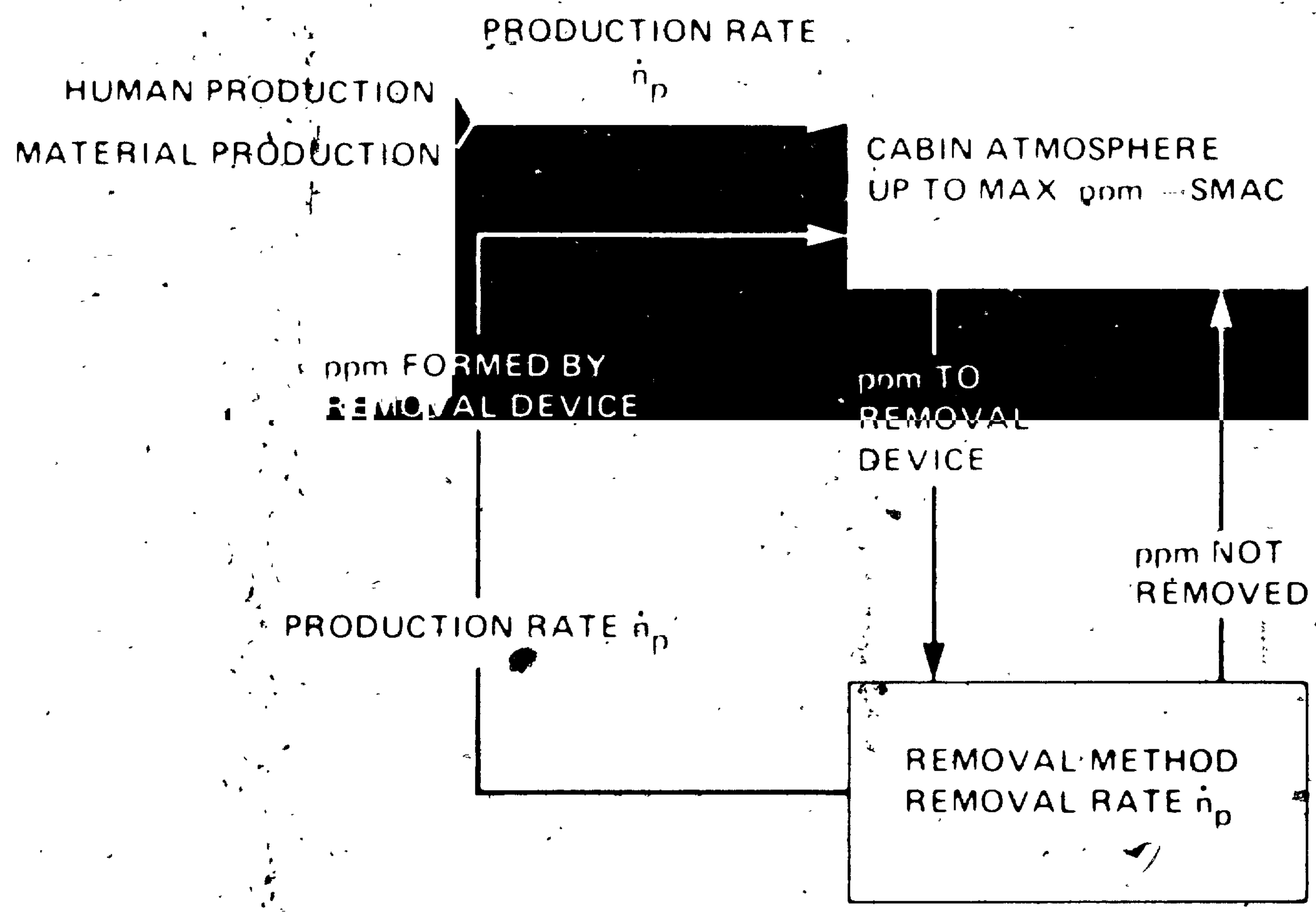
N85-29554

INTRODUCTION

This talk summarizes some of the potential problems associated with acid gas sorbents, activated charcoal beds and the catalytic oxidizer proposed for spacecabin trace contaminant control.

CONTAMINANT FLOW CYCLE IN CLOSED ATMOSPHERIC SYSTEM



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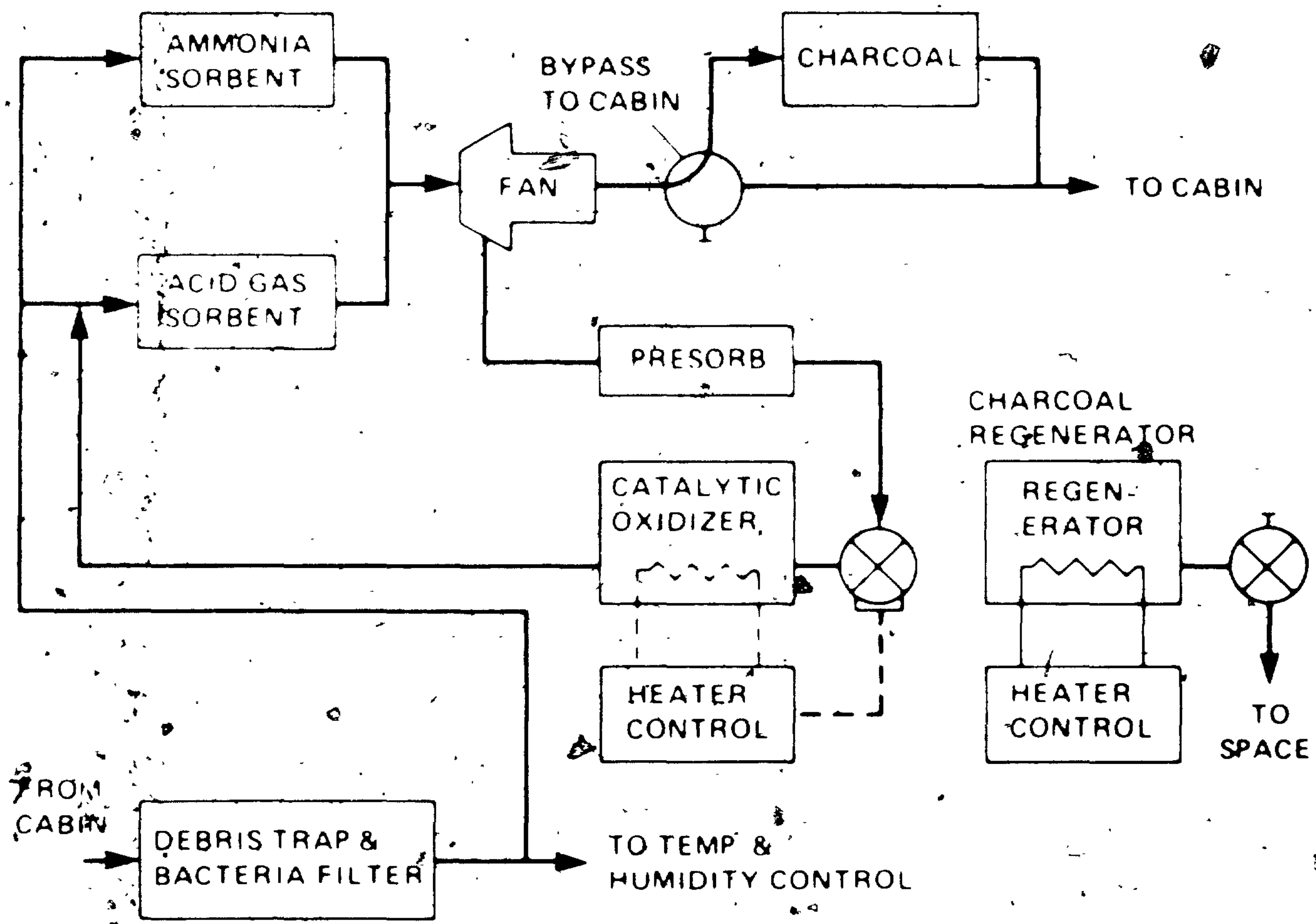
TRACE CONTAMINANT CONTROL SYSTEM PROPOSED FOR A SPACE STATION



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REPRESENTATIVE SPACECABIN CONTAMINANTS

Acetone
Acetaldehyde
Acetylene
Allyl Alcohol
Ammonia
Amyl Alcohol
Benzene
n Butane
Butene 1
cis Butene 2
trans Butene 2
n-Butyl Alcohol
Butyraldehyde
Butyric Acid
Carbon Disulfide
Carbon Monoxide
Chlorine
Chloroacetone
Chlorobenzene
Caprylic Acid
Chloropropane
Cyclohexane
Cyclohexanol
Cyanamide
1, 1-Dimethylcyclohexane
trans-1, 2-Dimethylcyclohexane
2, 2-Dimethylbutane
1, 4-Dioxane
Dimethylhydrazine
Ethyl Alcohol
Ethyl Acetate
Ethylene Dichloride
Ethylene
Ethylene Glycol
trans 1 M[illegible] ethylcyclohexane
Ethyl Sulfide
Ethyl Mercaptan
Freon 1[illegible]
Freon 1[illegible]
Freon [illegible]
Freon [illegible]
Freon 11[illegible]
Freon 11[illegible] Group [illegible]
Freon 1[illegible]

Formaldehyde
Hydrogen
Hydrogen Chloride
Hydrogen Fluoride
Hexene-1
n-Hexane
Hexamethylcyclotrisiloxane
Hydrogen Sulfide
Indole
Isopropyl Alcohol
Isobutyl Alcohol
Methylene Chloride
Methyl Chloroform
Methyl Ethyl Kentone
Methyl Isopropyl Ketone
Methyl Alcohol
3-Methyl Pentane
Methane
Monomethylhydrazine
Methyl Mercaptan
Nitric Oxide
Nitrogen Tetroxide
Nitrous Oxide
Propylene
Isopentane
n-Pentane
Propane
n-Propylacetate
Propyl Mercaptan
Phenol
Skatole
Sulfur Dioxide
Toluene
Trichloroethylene
Tetrachloroethylene
1, 1, 3 Trimethylcyclohexane
Tetrafluoroethylene
Freon 21
Valeric Acid
Vinyl Chloride
Vinylidene Chloride
m Xylene
o Xylene
p Xylene

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BOILING POINTS OF SPACECRAFT CONTAMINANTS

Component[1]	Normal Boiling[2] Point, °C
Acetronitrile (C_2H_3N)	81.8
Benzene (C_6H_6)	80.1
t-Butanol (C_4H_{10}[illegible])	82.9
Cyclohexane (C_6H_{12})	80.7
1,2-Dichloroethane	83.7
O-Dichlorobenzene ($C_6H_4Cl_2$)	179.0
Ethyl Acetate (C_4H_8[illegible])	77.1
Freon 12	-30
Freon 113	48.2
Furan (Furfuran) (C_4H_4[illegible])	32
Isopropanol (C_3H_8[illegible])	82.5
Methyl Chloroform (1,1,1 Trichloroethane) ($C_2H_3Cl_3$)	74.2
Methylethylketone (C_4H_8[illegible])	79.6
Vinyl Chloride (C_2H_3Cl)	-13.8

(1) Green, B. D and J. [illegible], [illegible] 99, Third European Electro-Optics Conference [illegible], 32

(2) CO_2 condenses (to solid) at -78.5°C at 1 atm

BASIC ADSORBENT BEDS AS ATMOSPHERIC CONTAMINANT REMOVAL DEVICES

- BASIC ADSORBENT BEDS HAVE BEEN SHOWN TO REMOVE – CO_2, HCl, H_2S, Cl_2 AND SO_2 WITH SOME EFFECTIVENESS AND TO BE INEFFECTIVE FOR NO_2, CH_3SH, AND CHF_3 (FREON 23)

- DATA ON ADSORPTION OF ALL CONTAMINANTS ON BASIC BEDS IS INCOMPLETE WITH RESPECT TO EFFECT OF TEMPERATURE, CO_2 CONC, HUMIDITY, CONTAMINANT CONCENTRATION, REACTION RATES, AND BED CAPACITIES – NO DATA IS AVAILABLE FOR MANY CONTAMINANTS

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CONTAMINANT CONTROL BY ADSORPTION ON BASIC BEDS

$LiOH$, Li_2CO_3, MnO_2, Na_2CO_3, $CaCO_3$

- PROBLEM OF DETERMINING WHAT SPECIES WILL BE ADSORBED AND WHAT CONDITIONS FAVOR ADSORPTION
- PROBLEM OF ADSORPTION RATE AND BED CAPACITY IN STOICHIOMETRIC GAS–SOLID REACTION

IDENTIFIABLE RESEARCH AREA

INVESTIGATIONS SHOULD BE MADE OF

- THE RANGE OF CONTAMINANTS REMOVABLE BY A BASIC ADSORBENT BED.
- THE STABILITY OF REMOVAL EFFICIENCIES FOR HCl, HF, Cl_2 AND F_2 IN EXTENDED SERVICE
- THE REASON FOR LOW NO_x AND SO_2 REMOVAL EFFICIENCY
- TEMPERATURE AND HUMIDITY OPTIMIZATION AND THE COMPATIBILITY OF OPTIMIZED CONDITIONS WITH OTHER SUB SYSTEMS

ATMOSPHERIC TRACE CONTAMINANT CONTROL BY CATALYTIC OXIDATION
PROBLEM OF MULTIPLE OXIDATION PRODUCTS

- INLET SPECIES
  H_2O O_2, NH_3, RH RS RX, RN, N_2
- REACTOR AT 300 700 F
  Pt, Pd/Al_2O_3 OR MnO_2; CuO AgO
- POSSIBLE RADICAL SPECIES IN BED
  R·, H·, O·, X·, N·, S·, O-O·, ·OH
- POSSIBLE EFFLUENT SPECIES
  CO_2, H_2O, R-O-R, $\overset{O}{\parallel}$H, HX, NO, N_2O, NO_2, N_2O_4, N_2, SO_2, R'X, X_2
- HIGH TEMPERATURE NEEDED FOR DIFFICULT TO OXIDIZE SPECIES
- SPECIES FRAGMENTS IN REACTOR CAN COMBINE TO FORM NEW COMPOUNDS
- H_2O + CO_2 ARE DESIRED PRODUCTS BUT CANNOT BE FORMED BY X, N, S COMPOUNDS
- NUMBER OF ACTIVE SITES FOR OXIDATION OF ANY PARTICULAR SPECIES LIMITED BY COMPETITIVE ADSORPTION OF OTHER SPECIES
- SUSTAINED CATALYST ACTIVITY DEPENDS ON MAINTENANCE OF PHYSICAL STRUCTURE AND CHEMICAL ACTIVITY AVOID SINTERING AND POISONING

CATALYTIC OXIDATION OF ATMOSPHERIC TRACE CONTAMINANTS

IDENTIFIABLE RESEARCH AREA

- EVALUATE THE DESIRABILITY AND EFFICIENCY OF CATALYTIC OXIDATION AS A TRACE CONTAMINANT CONTROL METHOD WHEN FEED GAS CONTAINS COMPOUND OF NITROGEN, SULFUR, AND THE HALOGENS
    - INVESTIGATE PRODUCT IDENTIFICATION AND MASS BALANCE WITH S, N, OR X COMPOUNDS IN FEED
    - INVESTIGATE TRANSIENT REDUCTIONS IN ACTIVITY OF CATALYST BED CAUSED BY S, N, OR X COMPOUNDS IN FEED
    - INVESTIGATE PERMANENT LOSS IN CATALYST ACTIVITY OR POISONING FROM S, N, OR X COMPOUNDS IN FEED

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SPECIFIC PROBLEMS IN ATMOSPHERIC TRACE CONTAMINANT REMOVA

CONTAMINANT CONTROL BY ADSORPTION ON CHARCOAL BEDS

PROBLEM OF BLOCKING OF ADSORPTION OF LIGHTER (MORE VOLATILE) SPECIES BY

- HEAVIER (LESS VOLATILE) CONTAMINANT SPECIES
- CONTAMINANT SPECIES REACTING OR CHEMISORBING ON CHARCOAL
- WATER ADSORBED FROM HUMID INLET GAS STREAM

ATMOSPHERIC TRACE CONTAMINANT CONTROL BY ADSORPTION ON CHARCOAL BEDS

WORK TO DATE HAS SHOWN HUMIDITY OF INLET GAS STREAM MAY:

- REDUCE ADSORPTION
- ENHANCE ADSORPTION
- PREFERENTIALLY BLOCK SOME SPECIES
- CHANGE OPTIMUM BED TEMPERATURE FOR CONTAMINANT REMOVAL

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IDENTIFIABLE RESEARCH AREA: HUMIDITY EFFECTS

INVESTIGATIONS ARE NEEDED TO:

- CONFIRM BLOCKAGE EFFECTS OF WATER VAPOR
- INVESTIGATE HUMIDITY EFFECTS IN ADSORPTION OF SO_2, DIMETHYL HYDRAZINE, MONO-METHYL HYDRAZINE, DIOXANE, CYANAMIDE, HCN, METHYL ETHYL KETONE, N_2O_4, ETHYLENE GLYCOL, ALLYL ALCOHOL AND OTHER POLAR CONTAMINANTS
- PROVIDE MORE RELIABLE GENERALIZED EXPRESSIONS FOR HUMIDITY EFFECTS TO AID DESIGN ANALYSIS FOR MISSION REQUIREMENTS

NEED FOR FURTHER RESEARCH ON ATMOSPHERIC TRACE CONTAMINANT CONTROL METHODS

- NO ONE METHOD CAN DO COMPLETE TASK
- IMPORTANT PROBLEMS REMAIN LARGELY UNSOLVED PREDICTION OF EFFECTS OF CONTAMINANT MIXTURES HUMIDITY VARIATION AND OFF DESIGN LOADS BED REGENERATION AND LONG TERM ACTIVITY
- MORE DEFINITIVE EXPERIMENTS ARE NEEDED TO PROVIDE THE DESIGN DATA NECESSARY FOR CONTAMINANT CONTROL SYSTEMS WITH
  - HIGHER RELIABILITY FACTOR
  - BETTER USE OF WEIGHT AND VOLUME AVAILABLE
  - LOWER POWER PENALTY
  - GREATER MARGIN FOR COMFORT AND HEALTH
- INTERFACE MUST BE MAINTAINED BETWEEN CONTROL METHODS RESEARCH AND MATERIALS AND PHYSIOLOGICAL RESEARCH AND DESIGN ENGINEERING